



The Research of Cooling Load and Cooling Capacity Calculation Methods of Spinning Workshop

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Abstract

This article takes a spinning workshop of Xi'an region in summer as an example, calculated and contrasted each part cooling load of spinning workshop by using cooling load coefficient method and steady calculation method, it comes to a conclusion that the results of two algorithms are little different and using steady calculation method is simple and convenient. Then we research an air treatment method which collecting process exhaust separately in spinning workshop, and calculate required cooling capacity. We think this method is feasible and can calculate it accurately to avoiding the phenomenon that workshop required cooling capacity not enough by traditional cooling capacity algorithm. It has important practical significance.

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1. Introduction

Textile industry is one of important light industry in china. The textile workshop intensively depends on air-conditioning due to the demands of the textile craft, its power consumption accounts for about 15% to 25% ^[1] of all electrical. Over the years, the textile machine heat as the main part of the workshop, generally use the steady calculation method. Literature [2] thinks this method doesn't distinguish heat from cooling load, the outcome is that the cooling load of air-conditioning will be larger, then the capacities of air-conditioning will be larger, which makes the equipment is running at low efficiency and increasing the consumption of energy, so calculates cooling load of textile workshop by using cooling load coefficient method in order to strict distinguish heat from cooling load. This article takes a spinning

workshop of xi'an region of summer as an example in order to understanding the differences in details between the two algorithms, and calculates and contrasts cooling load by using these two algorithms. In addition, there is process exhaust in spinning workshop and the temperature is higher to 5~15°C than the workshop temperature^[3]. However, it is clearly unreasonable that designing air-conditioning system with the conventional way and it easily lead to a phenomenon that the workshop is lack of cooling capacity offering and the workshop is hotter and hotter. Therefore, we compare collecting process exhaust separately with fresh air in enthalpy, and make a decision on whether reusing or releasing in a scientific and energy-saving method. Through this method in this article calculating required cooling capacity of workshop, we offer an important basis for the design of air-conditioning in spinning workshop.

2. The Design Parameters, the Area and Heat Transfer Factor of Building Structure

This is a serrated workshop, outdoor design parameters of xi'an: dry bulb temperature is 35.1°C, wet bulb temperature is 25.8°C. Indoor design parameters of spinning workshop: dry bulb temperature is 30°C, relative humidity is 60%. Table 1 shows the number of machine and worker. Table 2 shows the area and heat transfer factor of building structure.

Cooling load of the workshop include building structure cooling load, spinning machine cooling load and heat of people. We usually don't turn on the light when the heat comes to maximum in day time for a serrate workshop. So the cooling load through heat-releasing of light can be ignored^[4].

2.1 Calculate cooling load for building structure by using steady calculation method

It is a simplified method to use steady calculated method. Reasonably select parameters according to the relevant stipulate of literature [5].

Table 1 the number of machine and maximum worker

Machine Name	Number	Number of Spindles (ten thousand)	Power (kW/ one machine)	Maximum number worker	
				type of work	number
A513	117	5	15	operation class	130
				dailyshift + management	30

Table 2 the area and heat transfer factor of building structure

Building StructureName	Roof	Gutter	Skylight	Skylight Wall	East and West Gable Wall
area (m ²)	5607.18	533.61	751.5	1863.72	103.36 × 2
heat transfer factor (W / m ² · K)	0.679	0.575	1.745	0.477	1.992

The process of calculation is ignored and the results in table 3.

2.2 Calculate cooling load for building structure by using cooling load coefficient method^[6]

We can calculate the building structure cooling load by using a method of “time after time” and the result is in table 4. It shows in above table that the largest cooling load is 119846.4W at 18:00 by using this method.

2.3 The cooling load through heat-releasing of spinning machine

There are 117 spinning machine of A513. Its nameplate power $N=15$ kW, load factor $n_1=0.8$, simultaneity factor $n_2=0.95$, heat migration factor $n_3=0.92$. Then calculate the cooling load:

$$Q = 1000nNn_1n_2n_3 = 1227096W$$

Table 3 building structure cooling load by using steady calculation method (w)

Roof	Gutter	Gable Wall and Skylight Wall	Skylight	Total
124884.95	11272.47	6633.90	72068.47	214859.8

Table 4 building structure cooling load by using cooling load coefficient method (W)

Time	Roof and Gutter	East Gable Wall	West Gable Wall	Skylight Wall	Skylight Insolation Heat Gain	Skylight Transient Heat Transfer	Total
14:00	32815.14	1112.81	1032.93	1786.88	33583.48	6137.2	76468.44
16:00	56216.87	1312.52	953.04	1873.11	30021.6	6609.29	96986.43
18:00	77018.41	1492.26	973.01	2131.81	32565.8	5665.11	119846.4
20:00	87852.54	1632.05	1152.75	2562.97	17809.42	2989.92	113999.7

2.4 The cooling load through heat-releasing of people

The cooling load of average people is 198 W, take the maximal number into consideration (a operation class + a dailyshift class + the number of management), calculate the people cooling load: $198 \times (130+25+5) = 31680W$.

2.5 Gather the cooling load of workshop in summer

Through the above calculation, we can obtained the total cooling load of workshop in summer by using cooling load coefficient and steady calculation. The data is in table 5.

We can see from table 5, the cooling load of machine in spinning workshop is the largest which takes 83.3%~89.0% in the total cooling load and the building structure is 8.7%~14.6%.

By contrast in table 5, it is a big difference between building structure cooling load through the two different methods and the relative error is 44.2%, and the result of the second method which is saving in the traditional buildings is much smaller.

But in a industry building where the heat of machine take a large ratio (such as the spinning workshop is about 80%) , the relative mistake is only 6.45% for the two methods and the first one is much simpler. So we think that the method of steady calculation is absolutely viable in the textile workshop where there is large machine's heat .

Table 5 the total cooling load of workshop by using cooling load coefficient and steady calculation (w)

Calculation Method	Building Structure Cooling Load	Machine Cooling Load	People Cooling Load	Total Cooling Load	$\frac{\text{Building Structure Cooling Load}}{\text{Total Cooling Load}}$	$\frac{\text{Machine Cooling Load}}{\text{Total Cooling Load}}$
steady calculation	214859.8	1227096	31680	1473635.8	0.146	0.833
cooling load coefficient	119846.4	1227096	31680	1378622.4	0.087	0.890

3 Ventilation and required cooling capacity of workshop

According to the cooling load coefficient method, we obtain the total cooling load. Further analysis ventilation and required cooling capacity of workshop. At present, many textile workshops adopt primary return air system, fresh air occupies 10%, air treatment process is shown in figure 1.

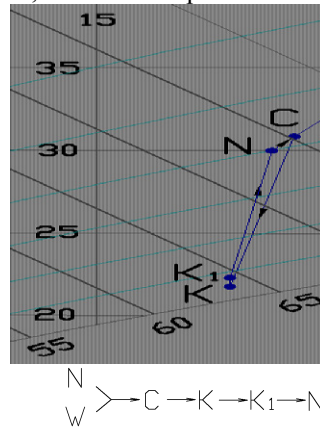


Figure 1 Air treatment process

3.1 The traditional method^[7]

3.1.1 Calculate air- supply

$$G = \frac{Q_y}{i_N - i_{K_1}} = \frac{1378622.4 \times 10^{-3}}{73.7 - 64.5} \times 3600$$

$$= 149.85 \times 3600 = 539460 \text{ kg} / \text{h}$$

$$L = \frac{G}{\rho} = \frac{539460}{1.2} = 449550 \text{ m}^3 / \text{h}$$

3.1.2 Calculate balance of air in traditional workshop (balance of ventilation)

To ensure the workshop at a positive pressure, and the positive pressure volume is 5% of the total air volume, the air volume of exhaust is 95%.

Calculate as follows:

(1) The positive pressure volume of workshop: $L_y = 0.05L = 22477.5 \text{ m}^3/\text{h}$

(2) The volume of exhaust: $L_{dp} = 0.95L = 427072.5 \text{ m}^3/\text{h}$

1) The volume of process exhaust It is $1600 \text{ m}^3/(\text{one machine} \cdot \text{h})$, and there is 117 in total in the workshop. The whole volume of process exhaust L_x is:

$$L_x = 117 \times 1600 = 187200 \text{ m}^3 / \text{h}$$

$$\frac{L_x}{L} = \frac{187200}{449550} = 41.6\%, \text{ It's } 41.6\% \text{ of total air volume.}$$

2) The volume of underground exhaust L_d is:

$$L_d = L_{d \cdot p} - L_x = 427072.5 - 187200 = 239872.5 \text{ m}^3 / \text{h}, \text{ It's } 53.4\% \text{ of total air volume.}$$

3.1.3 The required cooling capacity of traditional air-handling

The problem of traditional air-handling method is that it doesn't take the big temperature by process exhaust into account. But they handle the mixed cycle air with indoor air point N. the ratio of cycle air and fresh air is 9:1, the cooling requirement is:

$$\begin{aligned} Q &= G(i_c - i_k) = 539460 \times (74.6 - 63.9) \\ &= 5772222 \text{ kJ} / \text{h} = 1603.4 \text{ kW} \end{aligned}$$

3.2 The required cooling of improved air-handling style

The temperature of process exhaust of spinning workshop is generally 5~15°C higher than the workshop in summer, and the volume is very large which takes 41.6% of the total air volume. It is smallish for 1603.4kW if we calculate it in a traditional way. Now we improve the traditional air-handling style and collect the process exhaust alone .By the compare with outdoor air enthalpy , we decide whether to reuse the cycle air or to release it out.

Outdoor design parameters of xi'an :dry bulb temperature is 35.1°C, wet bulb temperature is 25.8°C, the enthalpy of outdoor air is 82.92kJ/kg through i-d diagram. When dry bulb temperature of process exhaust is 38.8°C(it has the same humidity with indoor cycle air) ,the enthalpy is still 82.92kJ/kg . when the temperature of process exhaust is over or equal to 38.8°C, all the rest is reused but 5% leave . when the temperature of process exhaust is greater than 38.8°C, all volume of process exhaust is released.

(1) When the temperature of process exhaust is 35°C , , the air-handling process is as follows in figure 2.

$$\begin{aligned} Q &= G(i_{c_1} - i_k) = 539460 \times (76.7 - 63.9) \\ &= 6905088 \text{ kJ} / \text{h} = 1918.1 \text{ kW} \end{aligned}$$

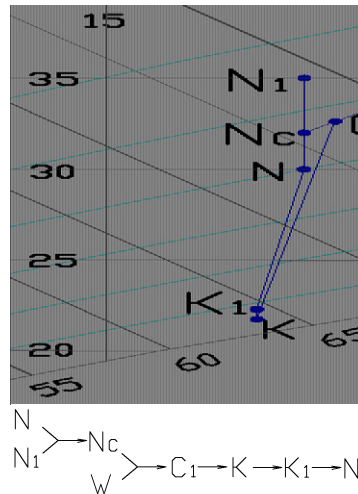


Figure 2 all the rest of process exhaust is reused

(2) When the temperature of process exhaust is 45°C, leave it all out, the process is as follows in figure 3.

$$\begin{aligned} Q &= G(i_{C_2} - i_K) = 539460 \times (78.0 - 63.9) \\ &= 7606386 \text{ kJ/h} = 2112.9 \text{ kW} \end{aligned}$$

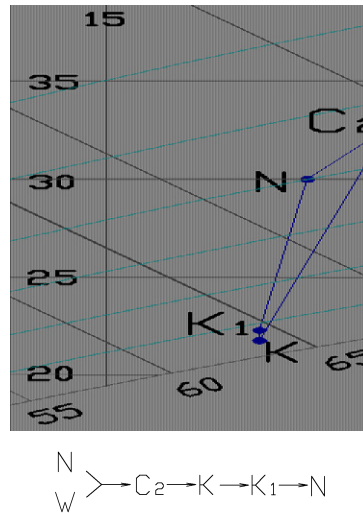


Figure 3 all volume of process exhaust is released

From the above analysis, we can see whatever you adopt process exhaust reuse or release it in summer, the enthalpy of mixed status points C_1 and mixed status points C_2 are greater than original mixed status points C , the required cooling capacity is also greater than the traditional algorithm. But this is not because of this improved style wasting energy, but the traditional way treats the temperature of process exhaust as the workshop's. It is obviously unrealistic, and the cooling requirement is much smaller, and it is easy to know that the temperature of process exhaust is higher, the traditional calculated value is much lower than actual cooling requirement. Then the temperature of workshop is rising and forming a vicious cycle.

4 Conclusions

(1) From the two methods of calculating the load of the workshop, we know that the load of the spinning machinery mainly lies in the equipment's. Although the method of cooling load coefficient is much less than the method of steady-state when we calculate building structure of load, there is no many differences between them in the total of workshop, and steady calculation method is more simple and efficient.

(2) As the temperature of the process exhaust is higher in summer, it must be considered when we calculate the cooling requirement of workshop. Collecting the process exhaust and comparing with the outside air enthalpy; when process exhaust enthalpy is less than outside air enthalpy, the majority is reused. When it higher than outsider air enthalpy, all is released. Through this method, the calculated value of cooling capacity can meet the actual needs of the workshop.

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